A Design Theory for e-Service environments: the interoperability challenge

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Abstract. The delivery of e-services across organizational boundaries poses a number of issues in terms of design of inter-organizational systems that support service delivery effectively. In this context interoperability emerges as a mandatory requirement for the design of Information Technology (IT) platforms supporting collaborative e-service environments. In this paper we address this issue by presenting a design theory for IT platforms supporting e-services based on both a deep understanding of the interoperability concept and a design research approach. Through the analysis of a cooperation framework developed in the context of an EU funded project, we instantiate the theory by providing the concrete example of a solution addressing this design problem.

Keywords: design theory, interoperability, IT platform

Introduction

The potential of value creation through the intensive cooperation of individual subjects and organizations has emerged as a new paradigm complementing the classical value chain model [1] since the beginning of the internet era. Normann and Ramirez introduced the concept of value constellation in 1993 [2] by underlining

differences between the two paradigms. The concept of value chain suggests that value is added, step by step, in any phase of the flow that starts from suppliers and ends to customers. Value is added, in sequence, by any actor involved in the product or service output. With the advent of advanced networking capabilities, economic activities are reformulated according to innovative temporal sequences, reallocated geographically and shared differently among economic actors leading to new configurations of production processes.

This reveals the importance of the emergence of a new business paradigm: the reconfiguration of value-creating systems [3]. That is to say, businesses are not only considered as competent actors, producing or establishing relationships with customers but are also seen as value makers. Rather, they see customers, suppliers, competitors and partners as potential players for co-producing and co-designing. Thus businesses are able to reorganize not only organizational borders but also business borders as well as entire business sectors. Notwithstanding these concepts are well accepted today in the strategic management literature, private and public administrations are more and more facing the problem of implementing IT platforms that effectively support these new forms of dynamic interactions. This is especially true in the domain of e-services where actors exchange information that can be easily managed through the support of IT systems. However especially in the e-Government domain we have assisted to the failure of several interoperability projects whose causes have been often generically assigned to political – informal – friction among public agencies.

Many positive impacts are expected as practical consequences of an effective interoperability achievement. For instance Chen and Doumeingts [4] claim that steps being made towards multidisciplinary interoperability research will lead to a substantial reorganisation of the research activities and cooperation in Europe. However achieving interoperability among different actors and their Information Systems is a non-trivial issue especially when value constellations encompass national boundaries and are subject to continuous reconfigurations.

In our view a deeper understanding of the interoperability concept can be the first step towards the definition of a set of properties and processes through which interoperability can be achieved effectively within inter-

organizational contexts. The objective of this paper is to deeply investigate this issue by providing both descriptive and prescriptive knowledge on this phenomenon.

With respect to Gregor's framework for classifying theories in Information Systems [5], we are addressing a research problem that ask for the development of a design theory for IT platforms supporting e-service environments. In fact, the majority of contributions available in the managerial literature on inter-organizational cooperation are aimed to analyze, explain, predict, or explaining and predicting the behavior of such socio-technical phenomenon. On the opposite, the technical literature on IT platforms supporting e-service collaboration has contributed with many technical solutions and new methods and techniques such as Service Oriented Architecture (SOA), Model Driven Architecture (MDA), Ontologies and Semantic Web, to name a few [6]. Despite these achievements are in line with the scope and objectives of service science, the effectiveness of available technologies, methods and techniques in addressing the field problem when applied to real contexts still demands a rigorous and careful evaluation. The assumption underpinning this claim is that service science belongs to the research stream of design science. This stream of research contributes to the knowledge base through theories for design and action that focus on "how to do something" and give explicit prescriptions on how to design and develop an artefact, whether it is a technological product or a managerial intervention [5]. Indeed services, together with their supporting IT platforms and managerial methods (i.e. Business Process Management) are human made artefacts whose effectiveness must be assessed and demonstrated.

In this paper we address the design problem of IT platforms supporting collaborative e-service environments. We base our design theory on a deep understanding of the interoperability concept and we instantiate the theory by presenting evidences collected in the context of a EU funded project aimed at fostering the cooperation among Chambers of Commerce and other public and private service providers, located in four EU countries, for the provision of innovative G2B services. The presentation of project results

allows us to instantiate the generalized design theory and to emphasize both explanatory and prescriptive aspects related to this field problem which have implication at both theoretical and practical levels.

The paper is structured as follows. First we introduce the research method. Then we analyze the interoperability concept in order to build the foundations of our design theory. Subsequently we illustrate the remaining components of the theory by instantiating them with the help of the empirical case. Finally we summarize findings and we underline the implications for research and practice.

The design theory framework

The problem of giving explicit prescriptions on how to design and develop an e-service environment belongs to what has been named as "IS design theory" by Walls et al. in their seminal work [7] inspired by Simon's [8] and Dubin's [9] contributions. In this article and in the following review and assessment in 2004 [10], Walls et al. distinguish two aspects of a design theory: the design product and the design process. The design product is composed by meta-requirements, meta-design (features), kernel theories and a set of testable design product hypothesis. Differently, the design process components are the design method, kernel theories and a set of testable design process hypothesis.

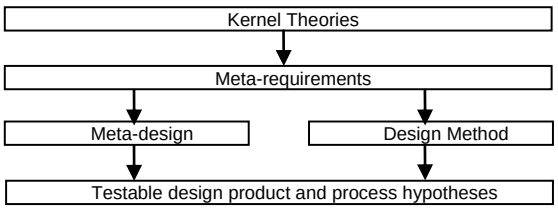

Fig. 1. Relationships among IS Design Theory components (Adapted from [10])

This model has been extended by Gregor and Jones [11] who have proposed a new "anatomical skeleton" for IS design theories, based on eight components which encompasses four issues identified in the Wall et al. conceptualization. For instance, the distinction between kernel theories for design processes and kernel theories for design products made by Walls et al. [10] has been criticized. For the purposes of the present work, we derive a model for formulating a design theory of e-service environments that lies on both the above mentioned frameworks. The model is based on five components whose relationships are depicted in figure 1. The rest of the paper is structured along the components of the above mentioned design theory which are illustrated in the following table.

Table 1. Components of the IS Design Theory (see [7][10])

Components	Description
Kernel Theory	The underlying knowledge or theory from the natural or social or design sciences that gives a basis and explanation for the design
Meta-requirements	The class of goals to which the theory applies
Meta-design	The abstract "blueprint" or architecture that describes an IS artifact, either product or method/intervention
Design methods	A description of processes for implementing the theory (either product or method) in specific contexts
Testable propositions	Truth statements about the design theory

Understanding interoperability

The term "interoperability" has been used many times in the literature without a shared and common definition. Many authors simply avoid offering a definition, and among the papers that do attempt to give a meaning, there is a surprisingly varied selection to choose from [12][13][14][15]. In this section, we aim to develop a common understanding of this term in order to identify the key elements of a kernel theory for deriving the meta-requirements of our design theory.

For some authors (information) interoperability is the ability of processes and systems to effectively exchange and use information services [16], while others provide a richer definition seeing it as "the ability of different types of computers, networks, operating systems, and applications, to exchange information in a useful and meaningful manner" [17]. These two definitions reflect perhaps a relatively technical perspective. This is understandable considering the historical context in which, ever since computerised networks began to support and interrelate more than one single unit of independent function, interoperability has been an important concern for systems development [18]. In this perspective the need for interoperability arises from the undeniable, exponential increase in system complexities and components, and their related coding and data processing requirements. In contrast with this technical view, other authors argue that interoperability is "more than getting bits and bytes to flow properly" [19]. In their view, within an Information Technology (IT) environment, the fundamental goal of interoperability is to overcome the challenge of assimilating people and organisations and to encourage the sharing of information – it is "people talking and sharing information".

A broader perspective on interoperability is suggested by Backhouse and Halperin [20] who see interoperable systems as something that goes far beyond the technical interconnectedness of databases and systems. In their view interoperability emerges from the need to communicate data across different domains for a specific purpose. In fact, while transferring data may represent a technical challenge because of different protocols, standards, and so forth, the key challenge highlighted by these authors is with the purpose, use and changes consequent on transferring that data. Changes in data ownership and custodianship have an effect on power structures, roles and responsibilities and on risk. These issues go well beyond the technical dimension into the formal and social spheres and ask for a holistic conceptual understanding of this phenomenon.

Using the TFI model to understand interoperability requirements

As a kernel theory for our design research purposes we refer to the work of Stamper et al. [21] which has already been applied to the information systems field as a powerful conceptual tool [22]. This model allows to analyse the interoperability phenomenon with a holistic perspective by viewing an information system as constituted of the technical, formal and informal (TFI) parts which are in a state of continuous interaction. Using the words of Stamper et al. [21] is it possible to illustrate this interrelation of abstracted layers explaining that, "Informal norms are fundamental, because formal norms can only operate by virtue of the informal norms needed to interpret them, while technical norms can play no role…unless embedded within a system of formal norm." In other words, the informal ways of managing information in organisations are critical and not always they can be replaced by rules or embedded in technical systems. With this view the informal elements (i.e. perception of risks, awareness, beliefs, culture, values, etc.), which are very context related, should drive the design and the selection of formal (policies, business processes, standards, procedures, etc.) and technical solutions (i.e. software and hardware platforms, network infrastructures, devices, etc.). In the context of information systems crossing the boundaries of a single organization (i.e. collaborative e-services), the relationship among these three levels is even more complex and requires to address additional issues such as the need to share a common understanding of basic concepts and their relationships in the domain of interest among involved members. Metaphorically, the TFI model can be viewed as a 'Russian doll' effect, were the informal is the outer shell containing the formal, which in turn contains the technical. Inside out, the technical cannot be removed from the toy without consideration for (unwrapping) the outer layers.

A Design Theory for IT platforms supporting e-Services: the LD-CAST case

The LD-CAST (Local Development Cooperation Actions Enabled by Semantic Technology) project focuses on the cooperation and integration of public institutions, allowing SMEs to access a multitude of cross-border G2B services and applications for business development in the context of the enlarged Europe. The cooperation framework and the service platform developed in the context of LD-CAST address all the three levels of interoperability according to the European Interoperability Framework (Organisational, Semantic and Technical interoperability) [23].

The main objective of the cooperation framework is to allow the LD-CAST Local Agencies to provide cross-border services to enterprises adopting the "business episodes" model, an end user centric approach. Each business episode is associated with the relevant actions and interactions with and between the LD-CAST Service Providers (mainly Chambers of Commerce, Public Bodies, local/national development agencies). In the context of e-Europe, this translates into defining services available to enterprises and the subsequent inter-organizational business processes that have to be managed by the Service Providers. The LD-CAST approach to this problem is based on a methodology and a platform support process composition both at design time introducing a first level of flexibility in the business process modelling activity and at run time focusing on service discovery to guarantee the satisfaction of user needs trough the adoption of semantic technologies [24].

From an architectural point of view the project adopted a distributed SOA in which the delivery of business services (i.e. the outcome of inter-organizational processes) is performed through an Execution Platform, which is driven by a Modelling Platform and is supervised by an Administration Platform. The Modelling Platform embeds semantic modules, while the Administration Platform implements a federated authentication and authorization infrastructure. For sustaining the rapid evolution of e-service demand expected in the near future, this approach allows multiple points of extension, like: designing new processes for new business services, registering new web services, enriching the ontology, annotating processes and web services with

ontology concepts, registering new local agencies and new service providers. In addition to the design, implementation and validation of the technological infrastructure supporting the cooperation among service providers, an exploitation strategy has also been defined. The LD-CAST business plan has been built upon the concept of the LD-CAST Global EU Agency, the point-of-sale of LD-CAST cross-border services, which correspond to an interoperable portal accessible (directly or indirectly through the Local Agencies) by the end users. The LD-CAST Global EU Agency is owned by a spinoff company (LD-CAST.org) that is entitled to carry out a number of activities both at a strategic and operational level. Among the operational level activities an important task performed by this central agency is the establishment of agreements with Local Agencies and Service Providers.

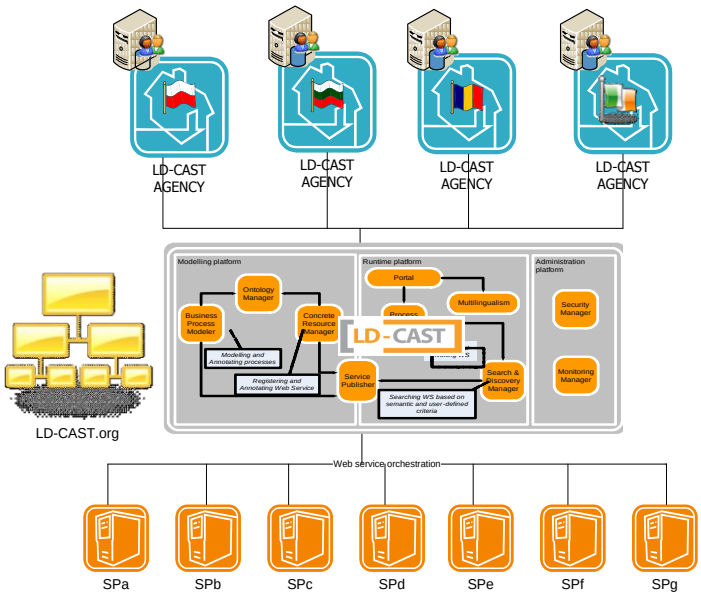

Fig. 2. The LD-CAST architecture

The Local Agency is the local distributor of the LD-CAST services to Local Agency's members (SMEs and entrepreneurs), while the Service Providers provide atomic business services orchestrated by the LD-CAST

Global EU Agency to create new complex services. It is important to note that Chambers of Commerce can play both the Local Agency role and the Service Provider role.

The evidences collected during the project confirm the relevance of our design problem by showing that developing an integrated social dimension for e-Government applications (in practice) poses difficult challenges. In fact, the multilevel, hierarchical nature of local, national and international public administrations, government procedures for production and dissemination of information are in fact overcomplicated, rigid, fragmented and dispersed. Despite the interoperability requirement for the LD-CAST project was already addressed in the project proposal phase, the actual design of an effective cooperation framework has required additional efforts to derive the meta-requirements driving both the implementation of the technical system (meta-design) and the methodology for implementing it (design method).

In figure 3 the main elements of the proposed theory are captured through the dimensions of the above mentioned framework.

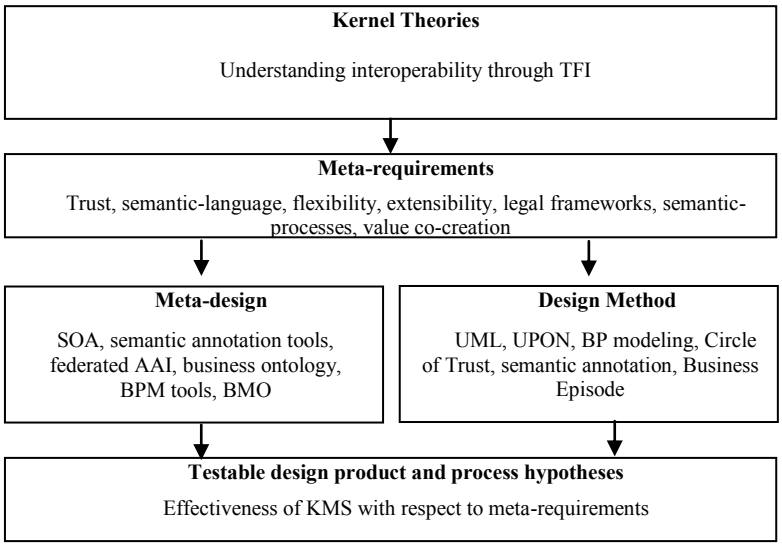

Fig. 3. A Design Theory for IT platforms supporting e-services

The holistic implementation of interoperability

The IT platform adopted in the LD-CAST project for enabling delivering in a trustful manner a multitude of cross-border services is based on SOA [25]. SOA allows the system to be easily adapted to new requirements and to assimilate new business services and new service providers, while the e-service demand evolves. The architecture supports a wide distribution of the deployed software artifacts; the flexibility and extensibility increase with the use of the second generation web services - discovered at runtime, sometimes on the basis of semantic web - involving the necessity to define ontologies.

Furthermore, an additional implementation of service oriented architectures has been adopted in the Administration Platform in order to face security and identity management issues posed by such a distributed system. The possibility to implement a federated identity management system based on the Liberty Alliance framework has been investigated during the technology selection phase of the project following the user requirements specification. The applicability of this technological solution together with the underpinning organizational model (i.e. Circle of Trust, Identity Provider, Service Provider) has represented an interesting argument to discuss also at a research level especially in the eGovernment domain [26].

To overcome problems related to the non-homogeneity of national terminology and processes around Europe, LD-CAST adopted an approach based on modeling processes at a high level of abstraction and using an ontology specific to the business domain. The web services are searched and discovered based on semantic technologies, quality criteria and client preferences. The business domain ontology may be used for characterizing modeling elements, like processes, activities, or implementation elements, like web services. On one hand, the ontology helps the domain expert to use a familiar language when dealing with the information system and, eventually, to introduce new concepts interactively into the system. On the other hand, the

concepts and their relationships may be used for defining criteria in order to perform various transformations and matches, as the discovery of web services at run time. Reference ontologies and their mapping on local ontologies has proven to be a viable solution for the interoperability of non-homogenous systems, with different European countries involved, and with stringent flexibility and extensibility requirements [26]. In order to build the LD-CAST Business Ontology the UPON (Unified Process for ONtology building) methodology has been adopted for capturing the knowledge of behind business processes in different national frameworks [28] . The description of the resulting ontology, which embeds more than 230 concepts divided in three levels, is out of the scope of this paper.

Interoperability issues at organizational level are mainly related to the differences among both legal frameworks involved and institutional and business goals of actors involved. The first issue required an in depth analysis of the legal frameworks (i.e. privacy regulations, etc.). Furthermore, the necessity to develop a business model to exploit the project results demanded for a debate among partners on aspects such as value configuration, technological infrastructure and market needs. Therefore a deeper analysis was needed in order to understand the multiple contexts involved and to find an agreement to define different strategies at a local level. These elements have an impact on the overall cooperation framework as they influence the choice of the most appropriate organizational configuration for the exploitation of project results. Also in this case research contributions have been published on the use of conceptual models (Business Model Ontology) and structured methods to develop a business model. Results of this analysis underline the communicative value of these tools when different stakeholders are involved in a collaborative business environment [29][30].

Towards an explorative design theory for IT platforms

A different perspective to analyze the findings of the LD-CAST project is based on the notion of explorative design theory [31]. In their recent paper Baskerville and Pries-Heje focus on the design product

aspects of a design theory by proposing a distinction between design practice theories and explanatory design theories. According to them an explanatory design theory explains why a generalized set of requirements is satisfied by a generalized set of object components. The essence of an explanatory design theory can be captured by representing the general requirements, which can be both conditions or capabilities, the general components and the relationships between them. Therefore general requirements and general components are related through a circular link representing the functional (teleological) relationship among them.

This leads us to move the first steps toward the development of a twofold contribution. First, a descriptive theory for functionally explaining the characteristics of IT platforms supporting e-service environments emerges from the relationship between requirements and components related to technical and formal interoperability. Second, a prescriptive design practice theory summarizes the methods and constructs which are relevant for managing the informal aspects of interoperability.

Future developments in this direction can contribute to the body of literature on the design of complex socio-technical systems. In fact, the LD-CAST cooperative framework can be considered as an instantiation of the generalized concept of "platform" as has been defined by Hanseth and Lyytinen in their article on the design of information infrastructures [32]. According to these authors, "platform designs draw upon architectural principles that organize IT capabilities into frameworks allowing the software to address a family of generic functional specifications that meet the needs of multiple, heterogeneous and growing user communities". The possibility to extend the IT capabilities of platforms is provided by design in the original architecture. Hence their evolution is governed and constrained by the initial specifications. The LD-CAST case provides an interesting instantiation of these generalized assumptions on IT platform design. By generalizing the requirements, the architectural choices and methods involved in this case we setup the basis for the development of a design theory for IT platforms from which our narrow theory on IT platforms supporting e-services inherits some of the capabilities, constraints and components.

Tab. 2. TFI view on the design theory elements

Requirements	*Components*		*Methods*
	Technical interoperability	*Formal interoperability*	*Informal interoperability*
trust	Federated AAI	Circle of Trust	Risk analysis
semantic-language	Semantic tools	Business ontology	Semantic annotation
flexibility	SOA, Sem tools	Business ontology	UPON
extensibility	SOA, Sem tools	Business ontology	UPON
legal frameworks	BPM, Sem tools	Business ontology	BP modelling
semantic-processes	BPM, Sem tools	Business ontology	BP modelling
value co-creation	-	Business Model On.	Business Episode

Conclusions

The cooperation among service providers operating remotely in a dynamic environment poses a number of interoperability issues at informal, formal and technical level. We address this problem by developing design theory for IT platforms supporting e-service environments. Our contribution is based on a deep understanding of the interoperability concept and on the evidences collected in the context of a EU project aimed to develop a platform and a cooperation framework for providing cross-border G2B services. Since the credibility of the generalization of a theory depends, among other factors, on the credibility assigned to the evidence [31], the main limitation of this research stands on the fact that this type of EU funded R&D projects are aimed to develop a proof of concept of a given system. Therefore, validating the relationships between kernel theories,

meta-requirements, meta-design, and design methods through a set of testable hypotheses was not possible after the pilot. Nevertheless, both the descriptive and prescriptive parts of this work provide a substantial contribution. In fact, the design practice theory projects the explanatory design theory into an instance while both provide interesting contributions to both practitioners facing the same field problem and to researchers investigating design problems which are either more general or more specific in nature.

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